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(54) **ENERGY DEMAND PREDICTION APPARATUS AND METHOD**

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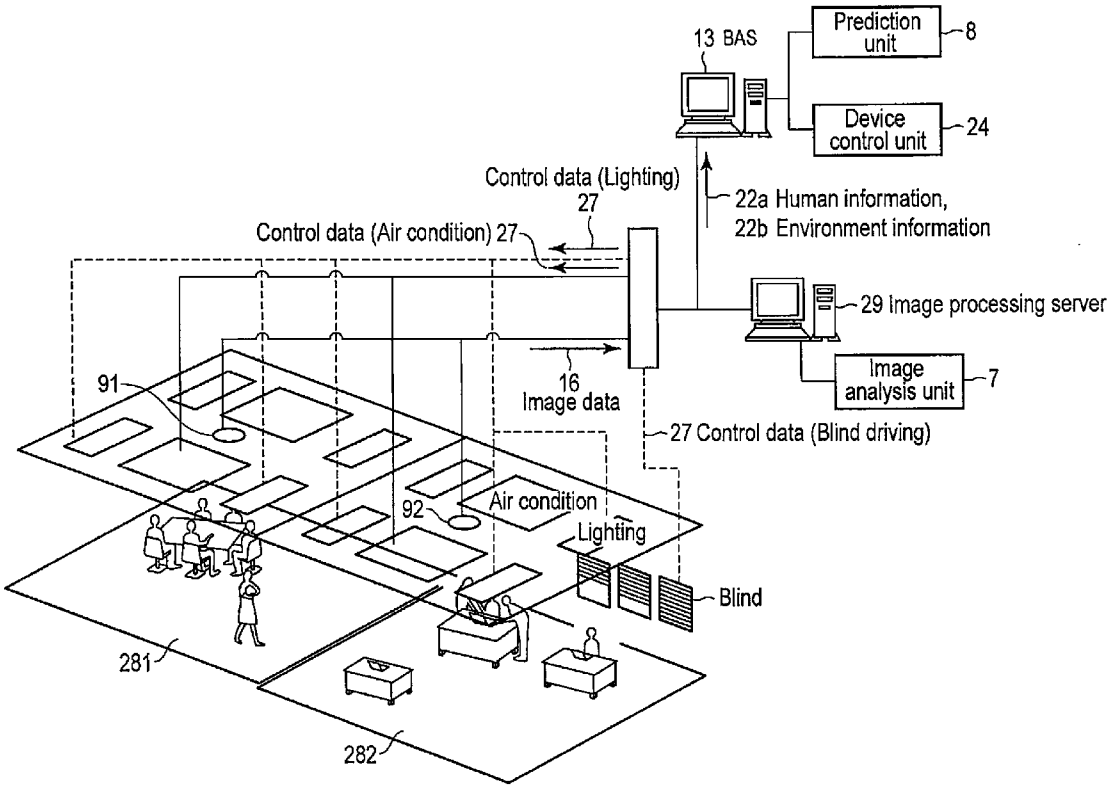
(57) **ABSTRACT**

An energy demand prediction apparatus according to an embodiment includes an image analysis unit and a prediction unit. The image analysis unit generates analysis data including at least one of human information and environment information of a prediction target area based on image data acquired by an image sensor. The prediction unit generates prediction data by executing an energy demand prediction based on the analysis data and an energy demand prediction model generated using previous data corresponding to the analysis data.



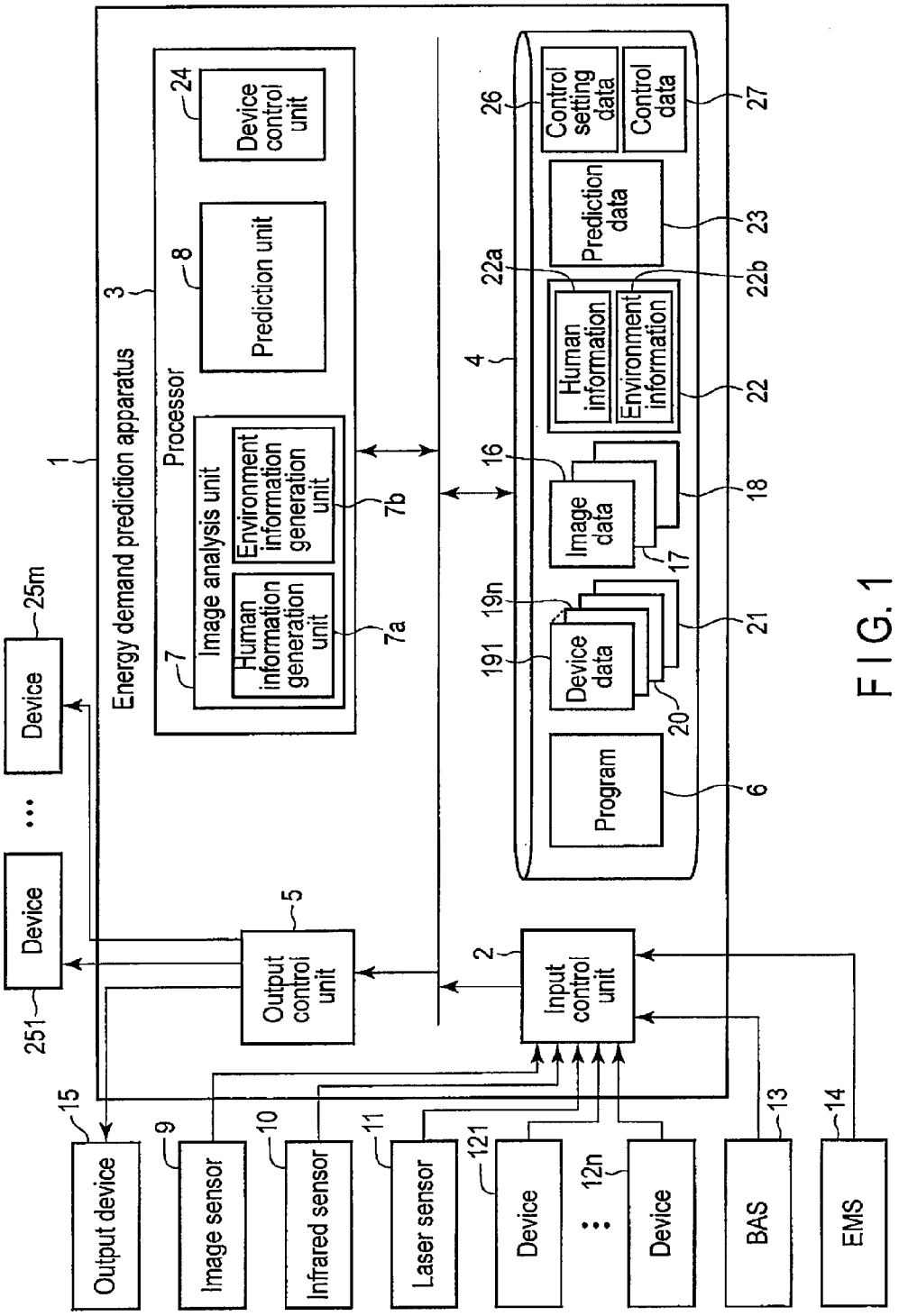

Energy demand prediction apparatus
1
Processor
3
Image analysis unit
7
Human information generation unit
7a
Environment information generation unit
7b
Prediction unit
8
Device control unit
24
Program
6
Device data
20
Image data
17
Human information
Environment information
22
Prediction data
23
Control setting data
26
Control data
27
Input control unit
2
Output control unit
5
Device
25m
Device
251
Output device
15
Image sensor
9
Infrared sensor
10
Laser sensor
11
Device
121
Device
12n
BAS
13
EMS
14

FIG. 1

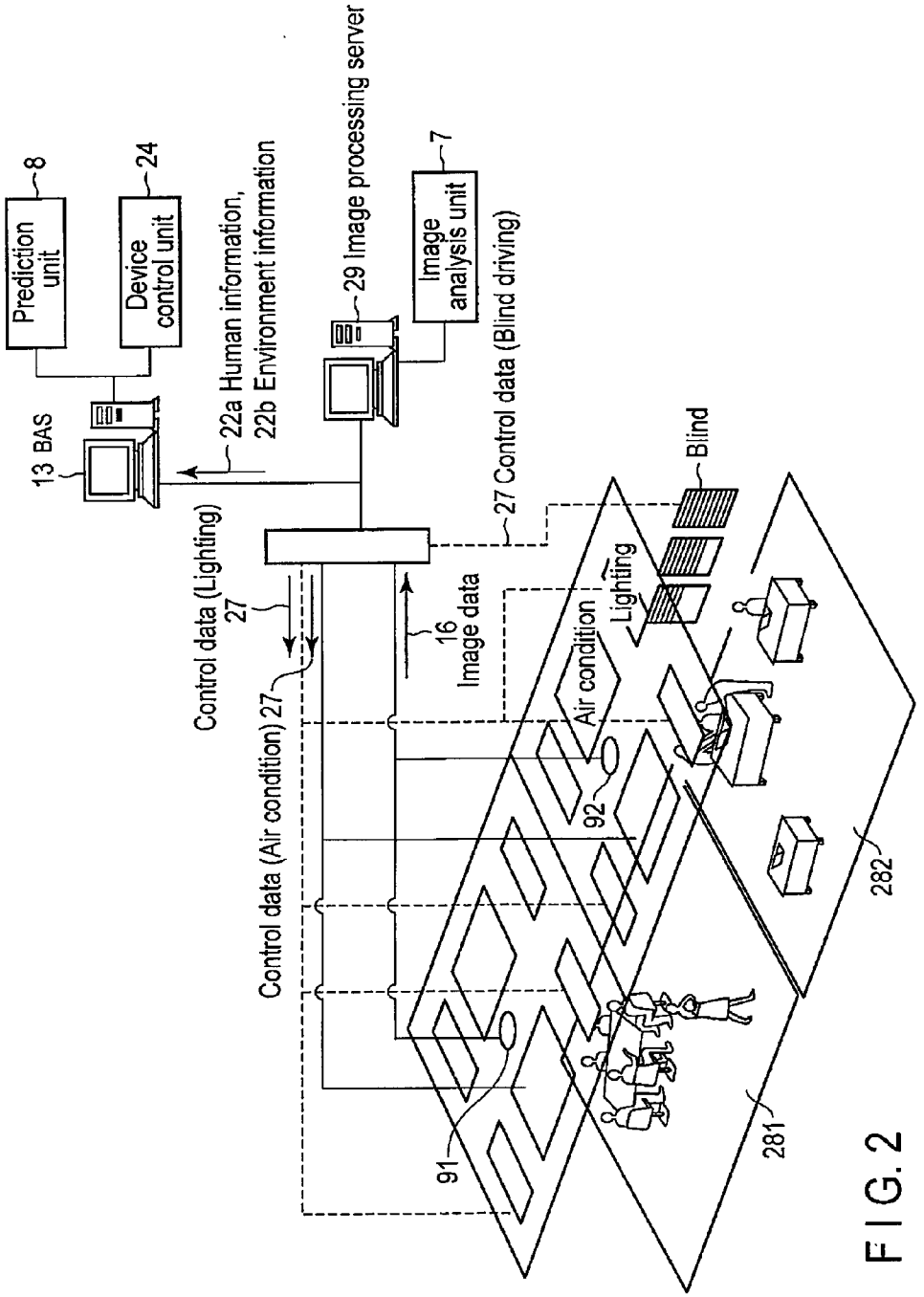

Prediction unit
8
Device control unit
24
29 Image processing server
Image analysis unit
7
13 BAS
22a Human information,
22b Environment information
27 Control data (Blind driving)
Control data (Lighting) 27
Control data (Air condition) 27
16 Image data
Blind
Lighting
Air condition
91
92
281
282

FIG. 2

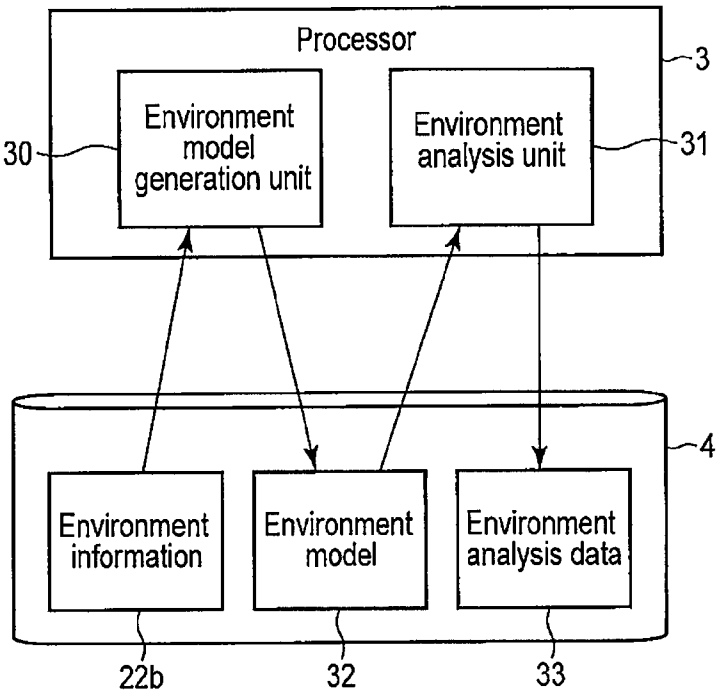

Processor
3
Environment model generation unit
30
Environment analysis unit
31
4
Environment information
Environment model
Environment analysis data
22b
32
33

FIG. 3

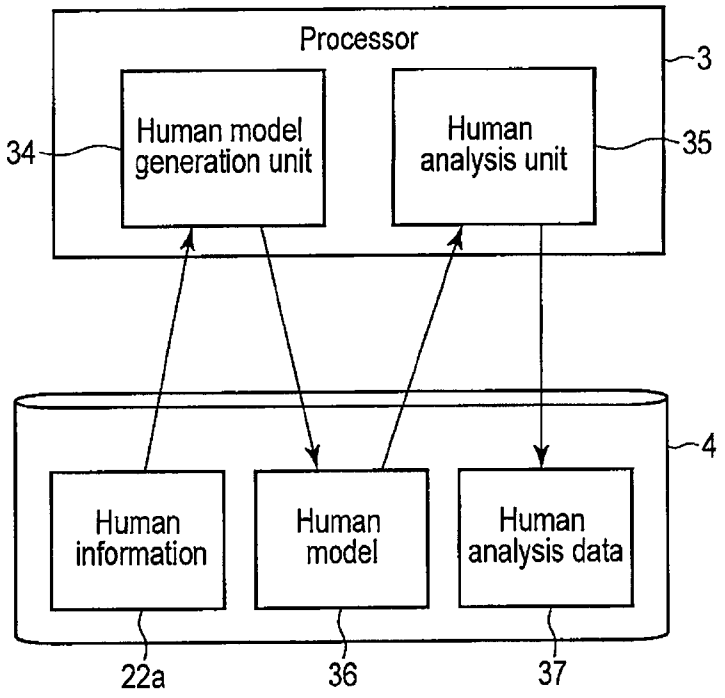

Processor
3
Human model generation unit
34
Human analysis unit
35
4
Human information
Human model
Human analysis data
22a
36
37

FIG. 4

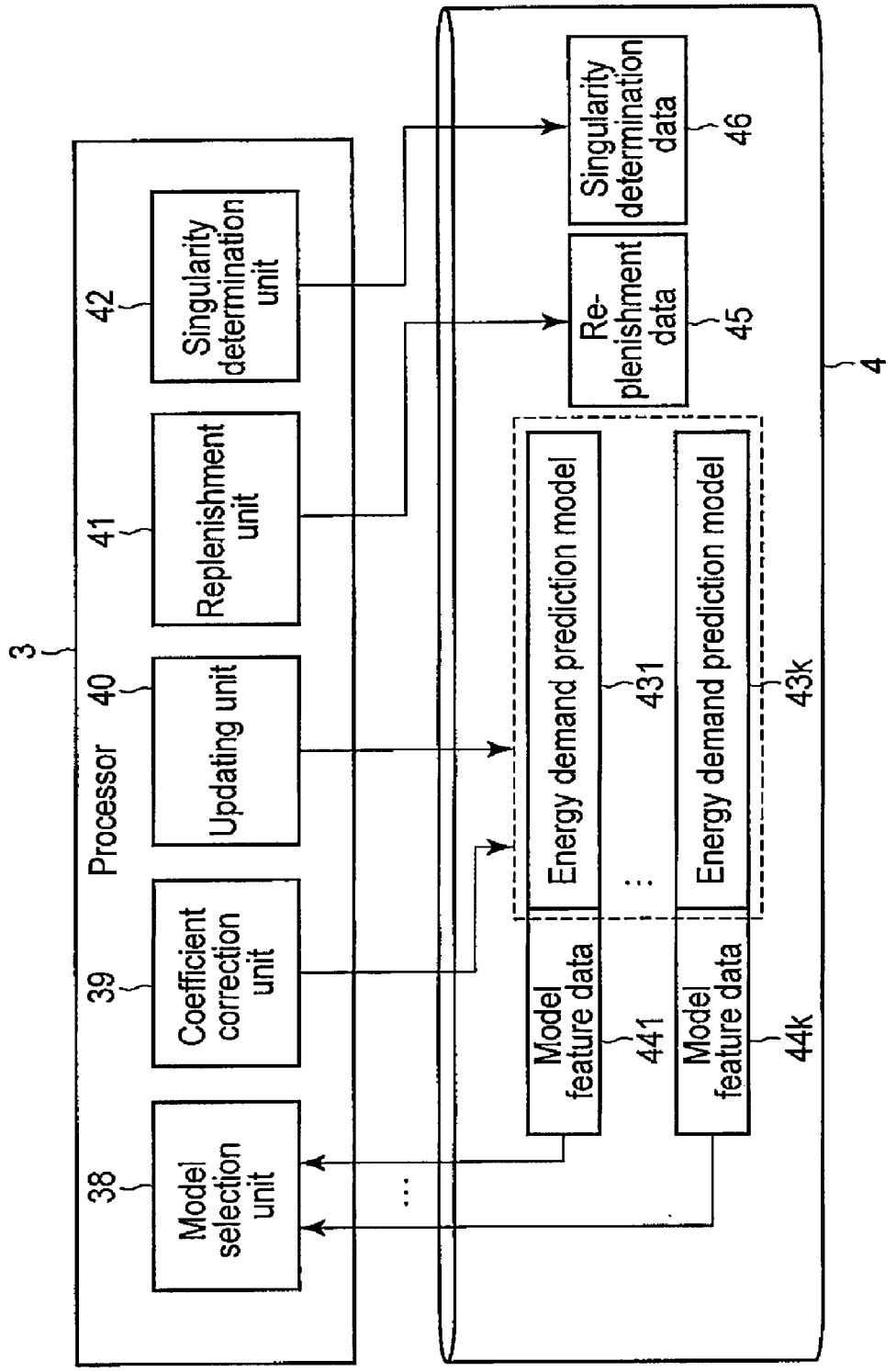

3
Processor
38
Model selection unit
39
Coefficient correction unit
40
Updating unit
41
Replenishment unit
42
Singularity determination unit
4
Energy demand prediction model
431
Energy demand prediction model
43k
Model feature data
441
Model feature data
44k
Re-plenishment data
45
Singularity determination data
46

FIG. 5

ENERGY DEMAND PREDICTION APPARATUS AND METHOD

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a Continuation Application of PCT Application No. PCT/JP2011/078684, filed Dec. 12, 2011 and based upon and claiming the benefit of priority from prior Japanese Patent Application No. 2011-057137, filed Mar. 15, 2011, the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] An embodiment of the present invention relate to an apparatus and method predicting an energy demand of various facilities.

[0004] 2. Description of the Related Art

[0005] In recent years, prevention of global warming and reduction of environmental loads have received attention. For example, it is required to make use of capabilities of apparatuses for energy saving, creation, and storage equipped in facility such as a building, factory, and plant, so as to attain unwasted and efficient energy management.

[0006] In order to attain energy management such as demand control, an accurate energy demand prediction is required.

[0007] As an example of the energy demand prediction, a method of executing the energy demand prediction based on information including electric power usages, weather, temperature, schedule (business day, no-business day, or singularity), and the like is available.

[0008] This conventional energy demand prediction uses, for example, measurement values of physical sensors such as a thermometer, hygrometer, illuminometer, and electric power data.

[0009] However, when the energy demand prediction is executed using only the measurement values of the physical sensors, the accuracy does not often suffice.

BRIEF SUMMARY OF THE INVENTION

Technical Problem

[0010] The embodiment of the present invention have as an object to provide an energy demand prediction apparatus and method, which improve an accuracy of an energy demand prediction.

Solution to Problem

[0011] In an embodiment, an energy demand prediction apparatus includes an image analysis unit and a prediction unit. The image analysis unit generates analysis data including at least one of human information and environment information of a prediction target area based on image data acquired by an image sensor. The prediction unit generates prediction data by executing an energy demand prediction based on the analysis data and an energy demand prediction model generated using previous data corresponding to the analysis data.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

[0012] FIG. **1** is a block diagram showing an example of an arrangement of an energy demand prediction apparatus according to a first embodiment;

[0013] FIG. **2** is a block diagram showing an example of an energy demand prediction system including the energy demand prediction apparatus according to the first embodiment;

[0014] FIG. **3** is a block diagram showing an example of an environment model generation unit and environment analysis unit according to a second embodiment;

[0015] FIG. **4** is a block diagram showing an example of a human model generation unit and human analysis unit according to a third embodiment; and

[0016] FIG. **5** is a block diagram showing an example of an arrangement of an energy demand prediction apparatus according to a fourth embodiment.

DETAILED DESCRIPTION OF THE INVENTION

[0017] Embodiments of the present invention will be described hereinafter with reference to the drawings. Note that the same reference numerals denote the same or nearly the same components throughout the accompanying drawings, a description thereof will not be given or a brief description thereof will be given, and only differences will be described in detail.

First Embodiment

[0018] This embodiment will explain an energy demand prediction apparatus, which analyzes image data acquired by an image sensor to generate image analysis data including at least one of human information and environment information, which dynamically change in an energy demand prediction area, and executes an energy demand prediction based on the image analysis data. Furthermore, in this embodiment, the energy demand prediction may be executed further using, for example, information such as a temperature, humidity, weather, schedule, electric power usages and the like in addition to the image analysis data.

[0019] The energy demand prediction apparatus according to this embodiment accurately measures, for example, data such as environment information, electric energy, and human activity information in an energy demand prediction area by analyzing the image data, thus attaining an accurate energy demand prediction.

[0020] FIG. **1** is a block diagram showing an example of an arrangement of the energy demand prediction apparatus according to this embodiment.

[0021] An energy demand prediction apparatus **1** includes an input control unit **2**, processor **3**, storage device **4**, and output control unit **5**.

[0022] The processor **3** functions as an image analysis unit **7**, prediction unit **8**, and device control unit **24** by executing a program **6** stored in the storage device **4**. Note that the image analysis unit **7**, prediction unit **8**, and device control unit **24** may be implemented by hardware in the energy demand prediction apparatus **1**.

[0023] The energy demand prediction apparatus **1** is connected to an image sensor **9**, infrared sensor **10**, laser sensor **11**, measurement devices **121** to **12***n*, building automation system (BAS: building monitoring system) **13**, and environment management system (EMS) **14** to be able to receive various data associated with an energy demand prediction area. Furthermore, the energy demand prediction apparatus **1** is connected to an output device **15** and control target devices **251** to **25***m*.

[0024] The image sensor **9** includes, for example, a camera, image capturing device, visible camera, or the like.

[0025] The infrared sensor **10** includes, for example, an infrared camera or the like.

[0026] The laser sensor **11** measures a laser beam. The laser sensor **11** includes, for example, a laser camera.

[0027] The devices **121** to **12***n* include, for example, physical sensors such as a thermometer, hygrometer, illuminometer, and electric power meter, and other devices. The devices **121** to **12***n* acquire a temperature, humidity, illuminance, electric power information, weather information, schedule information, and the like.

[0028] The BAS **13** controls, monitors, and manages air-conditioning, heat sources, illuminations, reception and transformation of electric energy, disaster prevention, security, and the like in a building.

[0029] The EMS **14** manages an environment of the energy demand prediction area.

[0030] The devices **251** to **25***m* include devices as control targets such as air-conditioner, lighting devices, blind driving devices, curtain driving devices, and the like, which are installed within the energy demand prediction area.

[0031] The input control unit **2** controls the storage device **4** to store image data **16**, infrared image data (infrared measurement data) **17**, and laser image data (laser measurement data) **18**, which are respectively acquired by the image sensor **9**, infrared sensor **10**, and laser sensor **11**.

[0032] Also, the input control unit **2** controls the storage device **4** to store device data **191** to **19***n* acquired by the devices **121** to **12***n*.

[0033] Furthermore, the input control unit **2** inputs BAS data **20** of the BAS **13** and EMS data **21** of the EMS **14**, and controls the storage device **4** to store these data.

[0034] The image analysis unit **7** executes analysis processing for the image data **16**, infrared image data **17**, and laser image data **18** stored in the storage device **4**, generates analysis data **22** including human information **22***a* and environment information **22***b*, and stores the analysis data **22** in the storage device **4**. The image analysis unit **7** implements functions as a human information generation unit **7***a* and environment information generation unit **7***b*.

[0035] The human information generation unit **7***a* extracts feature amounts from the image data **16**, infrared image data **17**, and laser image data **18**, and executes recognition processing and the like based on the extracted feature amounts and set criteria, thereby generating the human information **22***a*.

[0036] The human information **22***a* includes the presence/absence of a person, the number of persons, a distribution/density of the persons, an amount of activity of the person, an amount of clothing of the person, a personal attribute (name, gender, body type, body height, age, etc.), a position of the person (standing position, seated position, etc.), and an activity state (during office work, transfer, conversation, and so forth) of a person in the energy demand prediction area, personal specific information of a person who is in the energy demand prediction area, and the like.

[0037] The environment information generation unit **7***b* extracts a feature amount from the image data **16**, infrared image data **17**, and laser image data **18**, and executes recognition processing and the like based on the extracted feature amount and set criteria, thus generating the environment information **22***b*.

[0038] The environment information **22***b* includes light information such as an illuminance, amount of solar radiation, a blind opening/closing amount, incident state of sunlight, and the like, layout information such as the presence/absence, location, and number of office devices, the location and number of doorway and a window of an office, and a location of a path, the locations and numbers of heat sources and power consuming devices, weather information, and the like.

[0039] The prediction unit **8** executes the energy demand prediction based on the analysis data **22**, the device data **191** to **19***n*, the BAS data **20**, the EMS data **21**, and an energy demand prediction model (prediction formula) stored in the storage device **4**, and generates prediction data **23**. Then, the prediction unit **8** stores the prediction data **23** in the storage device **4**. In this way, using the analysis data **22** which changes dynamically in the energy demand prediction, a flexible and accurate prediction can be attained.

[0040] The energy demand prediction model is generated based on previous data including previous analysis data **22**, previous device data **191** to **19***n*, previous BAS data **20**, and previous EMS data **21**, and a previous energy consumption amount corresponding to this previous data. Using the energy demand prediction model, a future energy (electric power) demand prediction can be executed.

[0041] The device control unit **24** executes control processing for the control target devices **251** to **25***m* associated with the energy demand prediction area based on the prediction data **23**, the human information **22***a* and environment information **22***b* in the analysis data **22**, the device data **191** to **19***n*, and control setting data **26** stored in the storage device **4**, and generates control data **27** including at least one of control instructions and control values for the devices **251** to **25***m*. Then, the device control unit **24** stores the control data **27** in the storage device **4**.

[0042] In this case, the control setting data **26** includes individual user information, individual attribute data, and individual comfort state information of persons. Also, the control setting data **26** includes control values corresponding to human action states (an action sensitive to heat, that sensitive to the cold, during a desk work, during stand talking, during walking).

[0043] For example, the device control unit **24** generates the control data **27** based on the prediction data **23**, so that an energy demand fall within a predetermined value range. Thus, energy saving, creation, and storage can be attained.

[0044] Also, the device control unit **24** may generate the control data **27** for the devices **251** to **25***m* based on the human information **22***a* in the analysis data **22**, and the control setting data **26** including the user information, attribute data, individual comfort state information, and control values corresponding to personal actions, which are stored in the storage device **4**.

[0045] The device control unit **24** identifies an individual based on the human information **22***a*, and generates the control data **27** for practicing a comfort state set for this indi-

vidual in the control setting data **26**. For example, the device control unit **24** may generate the control data **27** for practicing control set for the action state in the control setting data **26** based on the human action state (an action sensitive to heat, that sensitive to the cold, during a desk work, during stand talking, during walking) included in the human information **22***a*.

[0046] The output control unit **5** outputs the prediction data **23** and various other data stored in the storage device **4** to the output device **15**.

[0047] Furthermore, the output control unit **5** outputs the control data **27** stored in the storage device **4** to the devices **251** to **25***m*.

[0048] The output device **15** includes, for example, a display device, audio output device, communication device, and the like, and displays, audibly outputs, and transmits the prediction data **23** and various other data.

[0049] The devices **251** to **25***m* operate based on the control data **27**. The devices **251** to **25***m* include, for example, air-conditioners, lighting devices, blind driving devices, and the like.

[0050] FIG. **2** is a block diagram showing an example of an energy demand prediction system including the energy demand prediction apparatus **1** according to this embodiment.

[0051] Image sensors **91** and **92** are installed respectively for energy demand prediction areas **281** and **282**. The image sensors **91** and **92** are installed on, for example, a ceiling of an office or an outdoor, and capture images of the office. The image sensors **91** and **92** may include a visible camera, infrared camera, and the like. Image data **16** acquired by the image sensors **91** and **92** are stored in a memory area, which is prepared in advance. The image analysis unit **7** of an image processing server **29** analyzes the captured image data **16** to generate the human information **22***a* and environment information **22***b*. The image processing server **29** transmits the human information **22***a* and environment information **22***b* to the BAS **13**. Note that the functions of the image analysis unit **7** may be included in the image sensors **91** and **92**. In this case, the need for the image processing server **29** can be obviated.

[0052] The BAS **13** executes generating the prediction data **23** by the prediction unit **8** and device controlling by the device control unit **24** using the human information **22***a* and environment information **22***b*, in addition to building management.

[0053] For example, the prediction unit **8** executes the energy demand prediction based on the human information **22***a* and environment information **22***b*, the device data **191** to **19***n* from other devices **121** to **12***n*, and the BAS data **20** which is used by the BAS **13** and includes device use states, electric power usages, and the like.

[0054] Note that the building management such as OK/NG determination of a human action, and the energy demand prediction by the prediction unit **8** may be executed by another computer in place of the BAS **13**.

[0055] The device control unit **24** specifies individuals who are staying in the energy demand prediction areas **281** and **282** based on the human information **22***a*. Also, the device control unit **24** specifies states (sensitive to heat, sensitive to the cold, etc.) and actions (during a desk work, during stand talking, during walking, etc.) of individuals based on the human information **22***a*. Furthermore, the device control unit **24** executes device control which matches attributes, states, actions, and favors of respective individuals based on attribute information and favor information of the individuals set in the control setting data **26**.

[0056] The control data **27** obtained as a result of the device control is transmitted to, for example, the control target devices **251** to **25***m* such as air-conditioners, lighting devices, blind driving devices, and the like.

[0057] In the aforementioned energy demand prediction apparatus **1**, an energy demand prediction model is generated to be able to predict an energy demand based on the human information **22***a* and environment information **22***b* in addition to information including the electric power usages, weather, temperature, schedule (business day, no-business day, or singularity), and the like.

[0058] The energy demand prediction model is built up using statistical predictions based on previous data, derivations of regression expressions for the previous data, use of physics formulas based on theories, and the like. For example, the prediction based on the energy demand prediction model is accurately done in real time. The energy demand prediction model built up with reference to the previous data executes future energy demand predictions based on actual state data of the energy demand prediction areas **281** and **282**.

[0059] Note that in this embodiment, image analysis uses data acquired by the image sensor **9**, infrared sensor **10**, and laser sensor **11**. However, all of these data need not always be used. That is, arbitrary one of the image sensor **9**, infrared sensor **10**, and laser sensor **11** may be installed. Alternatively, two or more sensors for at least one type of the image sensor **9**, infrared sensor **10**, and laser sensor **11** may be installed. Alternatively, data acquired by another sensor such as a thermo sensor (heat source sensor) may be used in image analysis. Alternatively, one or a plurality of acquired data may be selected and used in image analysis.

[0060] A practical example will be explained below. In this embodiment, the human information **22***a* is generated mainly using the image sensor **9**, and correspondence processing to a demand response (for example, an energy consumption reduction request from a power company) and demand prediction are executed based on this human information **22***a*. By contrast, for example, the human information **22***a* may be generated using a thermo sensor, laser sensor **11**, a sensor detecting a presence of person based on a technology, and the human information **22***a* may be used in the correspondence processing to the demand response and demand prediction.

[0061] In the aforementioned embodiment, The energy demand is predicted based on the human information **22***a* and environment information **22***b* generated based on the image data **16** in addition to the device data **191** to **19***n* acquired by the device sensors **121** to **12***n*. Thus, the prediction accuracy can be improved.

[0062] Also, using the image sensor **9** and image analysis unit **7**, the number of pieces of effective information used in the energy demand prediction can be increased without installing sensors of various other types, and information which changes dynamically can be effectively used in the prediction, thus attaining a cost reduction.

[0063] In this embodiment, the device control which matches an attribute of a recognized individual and reflects a personal favor can be executed based on the device data **191** to **19***n*, human information **22***a*, environment information **22***b*, and control setting data **26**.

[0064] In this embodiment, accurate and plenitude data, that is, the analysis data **22**, device data **191** to **19***n*, BAS data **20**, and EMS data **21** can be used as the previous data and actual state data.

[0065] In this embodiment, the accurate energy demand prediction model can be built up using information such as a temperature and humidity, which are measured using physical sensors such as the device sensors **121** to **12***n*, electric power information such as electric power usages of the devices **251** to **25***m* in the energy demand prediction area, and the human information **22***a* and environment information **22***b* acquired based on the image sensor **9**.

[0066] In this embodiment, the energy demand prediction, which can maintain an optimal energy balance, can be executed at year-, month-, day-, hour-, or second-intervals or in real time.

[0067] In this embodiment, the energy demand prediction can be executed for various energy demand prediction areas **281** and **282** such as a building, floors, areas, and zones.

[0068] In this embodiment, the electric power information can be measured or acquired by the BAS **13** or electric power meter. Furthermore, in this embodiment, electric power use states of the respective devices can be estimated for the respective energy demand prediction areas **281** and **282** based on at least one of the human information **22***a* and environment information **22***b*. In response to a demand response, the device control unit **24** selects a device, which is not in use but whose power supply is ON, based on the image data **16** from the image sensor **9**, and can turn off the power supply of the selected device. Therefore, in this embodiment, the device control unit **24** can flexibly executes control for the demand response.

Second Embodiment

[0069] This embodiment will explain the environment information **22***b* according to the first embodiment more practically.

[0070] As described above, the environment information **22***b* includes light information such as an illuminance, amount of solar radiation, blind opening/closing amounts, and incident amount of sunlight, layout information such as the presence/absence, locations, and number of office devices, the numbers and locations of doorways and windows, and a location of a path, the locations and numbers of heat sources and power consuming devices, weather information, and the like. The environment information **22***b* can be acquired by analyzing the image data **16** of the image sensor **9** installed in an office. For example, the illuminance can be calculated by setting, in advance, a luminance distribution on the image data **16** of a certain object under given conditions. Luminance levels according to illuminance levels are stored in a database based on a change in luminance on the image data **16** caused by a change in illuminance, and image sensor parameters. Learning or updating of illuminance calculations are made using illuminance and luminance levels stored in the database. As for a blind, the environment information generation unit **7***b* recognizes a location of the blind by means of object recognition for the image data **16** or manual inputs. Then, the environment information generation unit **7***b* detects a change of the blind in the image data **16**, and recognizes a opening/closing amount and opening/closing angle of the blind. The state, opening/closing amount, and opening/closing angle of the blind calculated from the image data **16** are stored in a database. Learning or updating associated with recognition of the opening/closing amount and opening/closing angle of the blind is done using the blind state, opening/closing amount, and opening/closing angle of the image data **16**, which are stored in the database.

[0071] The presence/absence and location of an office device, the number of office devices, and office layout information are obtained by executing recognition processing of an object such as office device and the like to the image data **16**. The representative office device (desk, chair, display, PC, printer, partition, whiteboard, etc.) is recognized using a measurement of an object shape, a relationship of an object layout, or a learning technique. A direction and a size of the object in the image data **16** change depending on a positional relationship between the image sensor **9** and the object. The environment information generation unit **7***b* absorbs such a change and correctly recognizes the object using various learning techniques and the like. Thus, at the time of, for example, a layout change of an office or the like, the need for the user to manually input information can be obviated, and the environment information generation unit **7***b* can instantaneously and automatically recognize a new layout. The image sensor **9** can be installed outdoors. The environment information generation unit **7***b* can generate weather information, spatial information of a building to be analyzed, and layout information of a surrounding building by analyzing the image data **16** of the outdoor. Also, the environment information generation unit **7***b* can generate information such as a longitude and latitude of a measurement place, and a direction of a building to be measured based on a positional relationship with the sun or stars.

[0072] Various kinds of information included in the environment information **22***b* may be able to be acquired from various dedicated sensors. However, by acquiring various kinds of information by analyzing the image data **16** obtained by the image sensor **9**, since the need for installing individual dedicated sensors can be obviated, a cost reduction can be achieved. Of the environment information **22***b*, the layout information, weather information, and the like can be acquired when they are manually input by a user. However, using the image sensor **9**, these pieces of information can be acquired in real time, thus obviating the need of user's manual inputs.

[0073] The environment information generation unit **7***b* can calculate and estimate, as the environment information **22***b*, a measurement value at a certain point, a measurement value within a designated range, a value of a whole room, a value of a whole floor, and a value of a whole building.

[0074] FIG. **3** is a block diagram showing an example of an environment model generation unit and environment analysis unit according to this embodiment. Note that FIG. **3** mainly shows components which are not shown in FIG. **1** above.

[0075] The processor **3** executes the program **6**, which is not shown in FIG. **3**, thereby implementing functions as an environment model generation unit **30** and environment analysis unit **31**.

[0076] The environment model generation unit **30** generates an environment model **32** of an energy demand prediction area using a model automatic generation technique (for example, a model automatic generation tool) based on the environment information **22***b* stored in the storage device **4**. For example, the environment model **32** represents a feature and characteristic of the environment. Then, the environment model generation unit **30** stores the environment model **32** in the storage device **4**.

[0077] The environment analysis unit **31** executes restoration of a three-dimensional space, estimation of a temperature and humidity, estimation of heat and wind, air-conditioning simulation, and the like based on the environment model **32**, and generates environment analysis data **33**. Then, the environment analysis unit **31** stores the environment analysis data **33** in the storage device **4**.

[0078] The output control unit **5** outputs the environment analysis data **33** to the output device **15**, which is not shown in FIG. **3**.

[0079] In this embodiment, the environment model **32** is built up based on the environment information **22***b*, and restoration of the three-dimensional space, estimation of the temperature and humidity, estimation of heat and wind, air-conditioning simulation, and the like can be executed based on the environment model **32**.

[0080] The environment information **22***b* may be used in combination with various kinds of information (for example, indoor and outdoor temperature and humidity values, a wind speed, a CO_2 concentration, weather, etc.) acquired by normal sensors, and information from the BAS **13**.

[0081] Furthermore, the environment information **22***b* can improve the measurement accuracy using the human information **22***a*.

[0082] The environment analysis unit **31** of this embodiment may predict a condition of another floor from a condition of one floor based on the environment information **22***b*.

Third Embodiment

[0083] This embodiment will explain the human information **22***a* according to the first embodiment more practically.

[0084] As described above, the human information **22***a* includes information such as the presence/absence of the person or the number of persons, the distribution, the amount of activity, the amount of clothing, the attribute (name, gender, body type, body height, age, etc.), the position (standing position, seated position, etc.), and the activity state (office work, transfer, conversation, etc.) of the person in the energy demand prediction area. The human information **22***a* is acquired by analyzing the image data **16** of the image sensor **9** installed in an office. The human information generation unit **7***a* extracts a motion of a person by analyzing a change in luminance in time and a spatial direction of the image data **16**. The human information generation unit **7***a* identifies a person and another object, and identifies its action and behavior. A target to be identified by the human information generation unit **7***a* is stored in a database, and a learning technique is applied to the identification by the human information generation unit **7***a*.

[0085] The human information generation unit **7***a* can calculate and estimate, as the human information **22***a*, a measurement value at a certain point, a measurement value within a designated range, a value of a whole room, a value of a whole floor, and a value of a whole building.

[0086] FIG. **4** is a block diagram showing an example of a human model generation unit and human analysis unit according to this embodiment. Note that FIG. **4** mainly shows components, which are not shown in FIG. **1** above.

[0087] The processor **3** executes the program **6**, which is not shown in FIG. **4**, thereby implementing functions as a human model generation unit **34** and human analysis unit **35**.

[0088] The human model generation unit **34** generates a human model **36** in an energy demand prediction area using a model automatic generation technique based on the human information **22***a* stored in the storage device **4**. For example, the human model **36** represents a feature and characteristic of a person. Then, the human model generation unit **34** stores the human model **36** in the storage device **4**.

[0089] The human analysis unit **35** executes an action prediction of a person and air-conditioning and lighting simulations according to the action of the person based on the human model **36**, and generates human analysis data **37**. Then, the human analysis unit **35** stores the human analysis data **37** in the storage device **4**.

[0090] The output control unit **5** outputs the human analysis data **37** to the output device **15**.

[0091] In this embodiment, the human model **36** in the energy demand prediction area is built up based on the human information **22***a*, and the action prediction, the air-conditioning and lighting simulations according to the action of the person, and the like can be executed based on the human model **36**.

[0092] The human information **22***a* may be used in combination with information from a building central monitoring system, entry/leave management system, and security system.

[0093] Furthermore, the human information **22***a* can improve the measurement accuracy using the environment information **22***b*.

[0094] The human analysis unit **35** according to this embodiment may predict a condition of another floor from a condition of one floor in association with the human information **22***a*.

Fourth Embodiment

[0095] This embodiment will explain modifications of the first to third embodiments described above.

[0096] FIG. **5** is a block diagram showing an example of an arrangement of an energy demand prediction apparatus according to this embodiment. FIG. **5** mainly shows only components which are not shown in FIG. **1** above.

[0097] The processor **3** executes the program **6**, which is not shown in FIG. **5**, thereby functioning as a model selection unit **38**, coefficient correction unit **39**, updating unit **40**, data replenishment unit **41**, and singularity determination unit **42**. These units will be described below.

[0098] [Model Selection Unit **38**]

[0099] The storage device **4** stores a plurality of energy demand prediction models **431** to **43***k*, and model feature data **441** to **44***k* which respectively indicate features of the plurality of energy demand prediction models **431** to **43***k*.

[0100] The plurality of energy demand prediction models **431** to **43***k* and the corresponding model feature data **441** to **44***k* are associated with each other.

[0101] The model feature data **441** to **44***k* are used as criteria required to select an appropriate model from the plurality of energy demand prediction models **431** to **43***k*.

[0102] The model selection unit **38** selects, based on data such as current (latest) human information **22***a*, current environment information **22***b*, and current device data **191** to **19***n*, model feature data which matches a content indicated by the current data from the model feature data **441** to **44***k*. Then, the model selection unit **38** selects an energy demand prediction model corresponding to the selected model feature data.

[0103] The prediction unit **8** executes an energy demand prediction based on the energy demand prediction model selected by the model selection unit **38**.

[0104] In this embodiment, a plurality of energy demand prediction models are prepared in accordance with previous data tendencies.

[0105] In this embodiment, an energy demand prediction model optimal to the current energy demand prediction area can be selected from the plurality of energy demand prediction models **431** to **43***k*. For example, even when previous data, which were referred to upon building up a certain energy demand prediction model, include the same weather or season as the current weather or season, when the number of persons in a room upon building up the model is different from the current number of persons in the room, the model selection unit **38** gives priority to a head-count condition over the previous weather or season, and selects an energy demand prediction model which matches the head-count condition.

[0106] Thus, the prediction accuracy can be improved.

[0107] [Coefficient Correction Unit **39**]

[0108] The coefficient correction unit **39** automatically corrects coefficients of the energy demand prediction models **431** to **43***k* based on data such as the acquired human information **22***a*, environment information **22***b*, and device data **191** to **19***n*. Thus, the prediction accuracy can be improved.

[0109] More specifically, the coefficient correction unit **39** corrects the coefficients of the energy demand prediction models **431** to **43***k* based on the current information or information including time-serial changes such as an increase or decrease in the number of persons in a building or floor, a weather or cloud condition, and incident sunlight. For example, when the number of persons on a floor is increased immediately, the coefficient correction unit **39** adjusts a coefficient corresponding to the number of persons, so as to build up an energy demand prediction model which matches the actual state, thereby minimizing a difference between an actual energy demand and a predicted value.

[0110] [Updating Unit **40**]

[0111] The updating unit **40** updates (sequentially updates) the energy demand prediction models **431** to **43***k* based on the current data such as the human information **22***a*, environment information **22***b*, and device data **191** to **19***n* every time a predetermined period elapses. For example, the updating unit **40** sequentially updates the energy demand prediction models **431** to **43***k* using data acquired a day ahead, data acquired an hour earlier, and data acquired a minute earlier. Updating of the energy demand prediction models **431** to **43***k* can use various model automatic generation techniques.

[0112] In this embodiment, the energy demand prediction models **431** to **43***k* are sequentially updated using not only the human information **22***a* and environment information **22***b* acquired by the image sensor but also the device data **191** to **19***n* such as electric power information, weather information, or the like, thus improving the prediction accuracy.

[0113] [Data Replenishment Unit **41**]

[0114] The data replenishment unit **41** calculates replenishment data **45** effective for the energy demand prediction based on the acquired data such as the human information **22***a*, environment information **22***b*, and device data **191** to **19***n*. Then, the data replenishment unit **41** stores the replenishment data **45** in the storage unit **4**.

[0115] For example, various components such as the model selection unit **38**, coefficient correction unit **39**, and updating unit **40** execute their processes using the replenishment data **45** calculated by the data replenishment unit **41**.

[0116] For example, when the electric power usages of the devices **251** to **25***m* cannot be directly acquired, the data replenishment unit **41** estimates the electric power usages of the devices **251** to **25***m* based on electric power information, the human information **22***a*, the environment information **22***b*, and the like, which can be acquired.

[0117] For example, the data replenishment unit **41** determines that a personal computer, which is placed in front of a working person, is ON, and estimates an electric power usage based on his or her attending time. As for a printer and a copying machine, their electric power usages are estimated in the same manner as that personal computer.

[0118] For example, the data replenishment unit **41** estimates an electric power user amount of each room based on an electric power user amount of a whole floor and attending conditions of respective rooms.

[0119] For example, the data replenishment unit **41** estimates or predicts use conditions of office devices based on a layout of each room and a distribution of the number of persons, and can reflect them to the energy demand prediction.

[0120] For example, the data replenishment unit **41** estimates or calculates a measurement item for an area without any sensors based on data of an area installed with a sensor.

[0121] For example, the number of persons of an area without any image sensor can be calculated by estimating flows of persons based on human information acquired from surrounding image sensors.

[0122] Thus, the prediction accuracy can be improved, and cost can be reduced compared to a case in which all values are measured using sensors.

[0123] [Singularity Determination Unit **42**]

[0124] The singularity determination unit **42** executes, for example, comparison processing with a threshold based on the acquired data such as the human information **22***a*, environment information **22***b*, and device data **191** to **19***n*, thus determining or predicting a singularity. Then, the singularity determination unit **42** stores singularity determination data **46** indicating a determination result in the storage device **4**.

[0125] For example, various components such as the model selection unit **38**, coefficient correction unit **39**, updating unit **40**, and data replenishment unit **41** execute their processes using the singularity determination data **46**.

[0126] A day (singularity) such as an anniversary of foundation of a company, which is different from a normal day, has an energy demand tendency different from the normal day. Hence, energy demands have to be carefully predicted.

[0127] For example, different energy demand prediction models are prepared for a business day and a singularity, and it is important to recognize the singularity. As a setting of the singularity, a schedule may be manually input. However, the same energy demand prediction as that of the singularity is often exhibited on an unexpected day. For this reason, the singularity determination unit **42** determines or predicts a singularity based on the image data **16** acquired by the image sensor **9**. Thus, an unexpected energy demand variation can be coped with in advance.

[0128] The singularity determination unit **42** determines or predicts a singularity using an increase or decrease in the number of persons, a flow of persons, the number of transferring persons, a head-count distribution on respective floors, their time-serial changes, and the like included in the human information **22***a* mainly obtained from the image data **16**. Thus, energy demand tendency of a whole building, whole floor, and whole room can be predicted, thus improving the energy demand prediction accuracy of the whole building.

[0129] For example, for a singularity, an energy demand prediction model can be switched.

[0130] Additional advantages and modifications will readily occur to those skilled in the art. Therefore, the invention in its broader aspects is not limited to the specific details and representative embodiments shown and described herein. Accordingly, various modifications may be made without departing from the spirit or scope of the general inventive concept as defined by the appended claims and their equivalents.

What is claimed is:

1. An energy demand prediction apparatus comprising:

an image analysis unit that generates analysis data including at least one of human information and environment information of a prediction target area based on image data acquired by an image sensor; and

a prediction unit that generates prediction data by executing an energy demand prediction based on the analysis data and an energy demand prediction model generated using previous data corresponding to the analysis data.

2. The energy demand prediction apparatus of claim **1**, wherein the previous data includes previous data acquired by a device sensor, and

the prediction unit executes the energy demand prediction based on the analysis data, data acquired by the device sensor, and the energy demand prediction model.

3. The energy demand prediction apparatus of claim **1**, further comprising:

a device control unit that generates, based on the human information including a identification result of a person and control setting data including a control value set for the person or an attribute of the person, control data which matches the person indicated by the human information; and

an output control unit that outputs the control data to a corresponding device.

4. The energy demand prediction apparatus of claim **1**, wherein the environment information includes at least one of light information, device layout information, and weather information, and

the energy demand prediction apparatus further comprises:

an environment model generation unit that generates an environment model which represents a feature of an environment of the prediction target area based on the environment information.

5. The energy demand prediction apparatus of claim **1**, wherein the human information includes at least one of headcount information, distribution information, activity amount information, clothing amount information, attribute information, and action information of persons, and

the energy demand prediction apparatus further comprises:

a human model generation unit that generates a human model which represents a feature of a person who are staying in the prediction target area based on the human information.

6. The energy demand prediction apparatus of claim **1**, further comprising:

a storage unit that stores a plurality of energy demand prediction models and a plurality of model feature data respectively indicating features of the plurality of energy demand prediction models in association with each other; and

a selection unit that selects, based on the analysis data, the energy demand prediction model associated with the model feature data which matches the analysis data,

wherein the prediction unit executes the energy demand prediction based on the analysis data and the selected energy demand prediction model.

7. The energy demand prediction apparatus of claim **1**, further comprising:

a coefficient correction unit that corrects a coefficient of the energy demand prediction model based on the analysis data.

8. The energy demand prediction apparatus of claim **1**, further comprising:

an updating unit that sequentially updates the energy demand prediction model based on the analysis data every time a predetermined period elapses.

9. The energy demand prediction apparatus of claim **1**, further comprising:

a data replenishment unit that estimates a value used in the energy demand prediction based on the analysis data.

10. The energy demand prediction apparatus of claim **1**, further comprising:

a singularity determination unit configured to determine a singularity based on the analysis data, and to generate singularity determination data indicating a determination result.

11. An energy demand prediction method by a computer, comprising:

generating analysis data including at least one of human information and environment information of a prediction target area based on image data acquired by an image sensor, and storing the analysis data in a storage device; and

generating prediction data by executing an energy demand prediction based on the analysis data stored in the storage device and an energy demand prediction model generated using previous data corresponding to the analysis data, and storing the prediction data in the storage device.

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